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MEMORANDUM
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APRIL 1968

THE THERMODYNAMICS OF THE SILICON CARBIDE/SILICON-CARBON VAPOR SYSTEM

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PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

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PREFACE

This RAND Memorandum is a continuation of a broad study originally requested in 1962 by the Scientific Advisor to the Physics Division, Research Directorate,* Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico.

It is a contribution to a better understanding of the complex problems involved in the physics of reentry bodies. Silicon carbide is the fourteenth of a series of ablative materials to be investigated by means of mathematical techniques similar to those used at RAND in the parametric study of certain low-molecular-weight compounds as nuclear rocket propellants.

The results of the investigation of graphite, polystyrene, polyethylene, phenol-formaldehyde resin, polyamide resin, teflon, silica, zirconia, magnesia, alumina, beryllia, calcia, and magnesium silicate, the first thirteen materials to be studied in the series, are reported in RAND Memoranda RM-3326-1-PR, The Thermodynamics of the Graphite/Carbon Vapor System; RM-3708-PR, The Thermodynamics of the Polystyrene/Hydrocarbon Vapor System; RM-3709-PR, The Thermodynamics of the Polyethylene/Hydrocarbon Vapor System; RM-3988-PR, The Thermodynamics of the Phenol-Formaldehyde Resin/Carbon-Hydrogen-Oxygen Vapor System; RM-4404-PR, The Thermodynamics of the Polyamide Resin (Nylon-6)/Carbon-Hydrogen-Oxygen-Nitrogen Vapor System; RM-4634-PR, The Thermodynamics of the Teflon/Fluorocarbon Vapor System; RM-4804-PR, The Thermodynamics of the Silica/Silicon-Oxygen Vapor System; RM-4907-PR, The Thermodynamics of the Zirconia/Zirconium-Oxygen Vapor System; RM-4943-PR, The Thermodynamics of the Magnesia/Magnesium-Oxygen Vapor System; RM-5042-PR, The Thermodynamics of the Alumina/Aluminum-Oxygen Vapor System; RM-5131-PR, The Thermodynamics of the Beryllia/Beryllium-Oxygen Vapor System; RM-5248-PR, The Thermodynamics of the Calcia/Calcium-Oxygen Vapor System; and RM-5337-PR, The Thermodynamics of the Magnesium Silicate/Magnesium-Silicon-Oxygen Vapor System.

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SUMMARY

The purpose of this study is the thermodynamic investigation of silicon carbide, SiC, over a range of temperatures up to 6000°K and pressures up to 10^3 atmospheres.

Two sets of equilibrium composition equations are used--one representing a pure gas phase, the other a heterogeneous system of gas and condensed (i.e., solid) silicon carbide. The gas phase of the heterogeneous chemical system, like the homogeneous gas phase, comprises 25 gaseous silicon-carbon species.

The results of the computational program are presented in both tabular and graphic form. The latter is a conventional Mollier diagram in which specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight or moles of condensed silicon carbide.

ACKNOWLEDGMENTS

This study involved a considerable amount of hand and machine computation. The efforts of the following RAND Physics Department staff members are gratefully acknowledged: Donald A. Brown, for his extensive programming and machine work; and Elizabeth J. Force, for her meticulous graphical presentation of the tabulated results.

CONTENTS

I. INTRODUCTION

This study considers a chemical system that under certain conditions of temperature and pressure is a pure gas mixture and under others is a disperse system, i.e., smoke. In this case the smoke is a gas that contains a condensed phase, solid silicon carbide, symbolized by SiC.

The following assumptions were made in the computations:

(1) Thermal equilibrium is maintained between the condensed particles and the gas phase.

(2) The pressure due to the thermal motion of the condensed particles can be neglected.

(3) The gas phase obeys the ideal-gas law.

(4) The volume coefficient of thermal expansion of the condensed phase is constant.

(5) The solid phase is cubic, or beta, silicon carbide.

(6) Silicon carbide does not decompose at 3259°K.

II. COMPOSITION EQUATIONS

In this study it is assumed that the gas formed by heating silicon carbide, SiC, at various pressures up to a temperature of 6000°K is a mixture involving twenty-five gaseous chemical species--C, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9, C_{10}, e^-, C^-, C_2^-, C^+, C^{+2}, C^{+3}, C^{+4}, C^{+5}, C^{+6}, SiC, Si_2C, SiC_2, Si, Si_2, Si_3--and one condensed species--SiC (solid). The presence or absence of a condensed phase makes it necessary to consider two distinct sets of chemical equations.

A. No condensed phase present. In terms of Si, C, and e^- as primary components 1, 2, and 3, the chemical equations for the secondary components, or derived species, are given by the expression

$$a_i Si + b_i C + c_i e^- = Si_{a_i} C_{b_i} e^-_{c_i}, \qquad (1)$$

where the coefficients a_i, b_i, and c_i have the following values:

			Component i	
a_i	b_i	c_i	Symbol	Number
	2		C_2	4
	3		C_3	5
	4		C_4	6
	5		C_5	7
	6		C_6	8
	7		C_7	9
	8		C_8	10
	9		C_9	11
	10		C_{10}	12
	1	1	C^-	13
	2	1	C_2^-	14
	1	-1	C^+	15
	1	-2	C^{+2}	16
	1	-3	C^{+3}	17

Component i				
a_i	b_i	c_i	Symbol	Number
	1	-4	C^{+4}	18
	1	-5	C^{+5}	19
	1	-6	C^{+6}	20
1	1		SiC	21
2	1		Si_2C	22
1	2		SiC_2	23
2			Si_2	24
3			Si_3	25

The mass-balance equations are

$$n_{Si} = 1 - \sum_{4}^{25} a_i n_i, \tag{2}$$

$$n_C = 1 - \sum_{4}^{25} b_i n_i, \tag{3}$$

and

$$n_{e^-} = - \sum_{4}^{25} c_i n_i, \tag{4}$$

where n_{Si}, n_C, and n_{e^-} are the numbers of moles of Si, C, and e^-, respectively, a_i, b_i, and c_i are the coefficients of Si, C, and e^-, on the left-hand side of Eq. (1), and n_i is the corresponding number of moles of component i.

The equilibrium equations are given by the expression

$$n_i = K_i (P/n)^{a_i+b_i+c_i-1} (n_{Si})^{a_i} (n_C)^{b_i} (n_{e^-})^{c_i}, \tag{5}$$

where n is the total number of moles of gas in the equilibrium mixture, P is the total pressure in atmospheres, and K_i is the thermodynamic equilibrium constant of component i computed on the basis of Eq. (1).

B. Solid SiC present. In terms of SiC (solid), C, and e^- as primary components 1, 2, and 3, the secondary components, or derived species, may be obtained from the following generalized chemical equation:

$$a_j SiC + b_j C + c_j e^- = Si_{a_j} C_{b_j} e^-_{c_j} . \qquad (6)$$

The coefficients a_j, b_j, and c_j, as well as the corresponding derived species, are listed in the following table.

			Component j	
a_j	b_j	c_j	Symbol	Number
	2		C_2	4
	3		C_3	5
	4		C_4	6
	5		C_5	7
	6		C_6	8
	7		C_7	9
	8		C_8	10
	9		C_9	11
	10		C_{10}	12
	1	1	C^-	13
	2	1	C_2^-	14
	1	-1	C^+	15
	1	-2	C^{+2}	16
	1	-3	C^{+3}	17
	1	-4	C^{+4}	18
	1	-5	C^{+5}	19
	1	-6	C^{+6}	0

Component j				
a_j	b_j	c_j	Symbol	Number
1			SiC	21
2	-1		Si_2C	22
1	1		SiC_2	23
1	-1		Si	24
2	-2		Si_2	25
3	-3		Si_3	26

The mass-balance equations are

$$n_{\underline{SiC}} = 1 - \sum_{4}^{26} a_j n_j, \tag{7}$$

$$n_C = - \sum_{4}^{26} b_j n_j, \tag{8}$$

and

$$n_{e^-} = - \sum_{4}^{26} c_j n_j, \tag{9}$$

where $n_{\underline{SiC}}$, n_C, and n_{e^-} are the numbers of moles of <u>SiC</u>, C, and e^-, respectively, a_j, b_j, and c_j are the coefficients of <u>SiC</u>, C, and e^-, in Eq. (6), and n_j is the corresponding number of moles of component j.

The equilibrium equations are obtained by considering the free energy F of the system and the partial molar free energy, or chemical potential, $\mu_x = \partial F/\partial n_x$ of each component. For an ideal gas

$$\mu_x = \mu_x^o + RT \ln (n_x P/n), \tag{10}$$

where μ_x^o is the chemical potential of component x in the standard state of unit partial pressure, R is the gas constant, T is the temperature, P is the pressure, and n is the total number of moles

of gaseous species in the mixture. The chemical potential for SiC is given by

$$\mu_{SiC} = \mu^{o}_{SiC} + (P - 1)\bar{V}_{SiC}, \tag{11}$$

where μ^{o}_{SiC} is the standard molar free energy for SiC, $\bar{V}_{SiC}$ is the molar volume of SiC, and P is the pressure of the system.

By combining Eqs. (10) and (11), keeping in mind that the subscript j refers to the derived species on the right-hand side of Eq. (6), the following expression is obtained

$$n_j = K_j \exp\left[a_j(P - 1)\bar{V}_{SiC}/RT\right] (P/n)^{b_j+c_j-1} (n_C)^{b_j} (n_{e^-})^{c_j}. \tag{12}$$

In Eq. (12), K_j is the thermodynamic equilibrium constant associated with the chemical reaction of Eq. (6) and is defined by the relation

$$\Delta F^{o} = \mu^{o}_j - a_j\mu^{o}_{SiC} - b_j\mu^{o}_C - c_j\mu^{o}_{e^-} = - RT \ln K_j. \tag{13}$$

At first glance, Eqs. (7), (8), (9), and (12) represent a mathematical system of twenty-five equations in twenty-five unknowns that, ordinarily, could be solved by simple iteration. From the standpoint of the Gibbs phase rule, however, the chemical system under consideration, consisting of one component and two phases, enjoys but one degree of freedom. This means that at an arbitrarily fixed temperature, solid and vapor are in equilibrium at a unique pressure which can be determined in the following manner.

The expression for the total pressure as the sum of the partial pressures is

$$P = \sum_{2}^{26} n_x P/n, \tag{14}$$

where n is the total number of moles of gas in the equilibrium mixture. In view of Eq. (12) the above expression becomes

$$P = P_C + P_{e^-} + \sum_4^{26} K_j (\exp a_j Q) (P_C)^{b_j} (P_{e^-})^{c_j}, \tag{15}$$

where P_C and P_{e^-} are the partial pressures of C and e^-, respectively, and Q represents the quantity $(P - 1)\bar{V}_{\underline{SiC}}/RT$. In like manner, Eqs. (8) and (9), when multiplied through by P/n and rearranged, become

$$\emptyset = P_C + \sum_4^{26} b_j K_j (\exp a_j Q) (P_C)^{b_j} (P_{e^-})^{c_j}, \tag{16}$$

and

$$\emptyset = P_{e^-} + \sum_4^{26} c_j K_j (\exp a_j Q) (P_C)^{b_j} (P_{e^-})^{c_j}, \tag{17}$$

where $\emptyset$ represents zero. Equations (15), (16), and (17) represent a system of three equations in three unknowns, P, P_C, and P_{e^-}, which can be solved by iteration. It is then a simple matter to solve for P_j, n_j, and n.

III. THERMODYNAMIC EQUATIONS

The molecular weight of the gas-SiC mixture is given by the relation

$$M = \frac{40.097}{\bar{n}}, \tag{18}$$

where 40.097 is the formula weight of the input material SiC and $\bar{n}$ is the total number of moles in the mixture.

The specific free energy (in calories per gram) of the mixture is given by the expression

$$f = \frac{1}{40.097}\left\{\sum^{g} n_i[\mu_i^\circ + RT \ln (n_i P/n)] + n_{SiC}\,[\mu^\circ_{SiC} + c(P-1)\bar{V}_{SiC}]\right\}, \tag{19}$$

which is derived from Eqs. (5) and (6). The summation is over all gaseous species. The constant c = 0.0242172 converts cc-atmospheres to calories.

The specific entropy (in calories per degree per gram) of the mixture is given by the expression

$$s = \frac{1}{40.097}\left\{\sum^{g} n_i[S_i^\circ - R \ln (n_i P/n)] + n_{SiC}\,[S^\circ_{SiC} - c\alpha_v(P-1)\bar{V}_{SiC}]\right\}, \tag{20}$$

where S_i° and S°_{SiC} are the standard molar entropy of component i and SiC, respectively, at a given temperature, and α_v is the volume coefficient of thermal expansion of SiC.

The specific enthalpy (in calories per gram) of the gas mixture is given by the expression

$$h = \frac{1}{40.097}\left\{\sum^{g} n_i H_i^\circ + n_{SiC}\,[H^\circ_{SiC} + c(1 - \alpha_v T)(P-1)\bar{V}_{SiC}]\right\}, \tag{21}$$

where H_i° and $H_{\underline{SiC}}^\circ$ are the standard molar heat content of component i and $\underline{SiC}$, respectively, at a given temperature.

The specific internal energy (in calories per gram) of the mixture is given by the expression

$$u = \frac{1}{40.097}\left\{\sum^{g} n_i(H_i^\circ - RT) + n_{\underline{SiC}}\left[H_{\underline{SiC}}^\circ - c[1 + (P-1)\alpha_v T]\tilde{V}_{\underline{SiC}}\right]\right\}. \tag{22}$$

The terms representing the increase in a thermodynamic property from one atmosphere to P atmospheres for $\underline{SiC}$, namely,

$$\Delta F = (P-1)\tilde{V}_{\underline{SiC}}, \tag{23}$$

$$\Delta S = -\alpha_v(P-1)\tilde{V}_{\underline{SiC}}, \tag{24}$$

$$\Delta H = (1 - \alpha_v T)(P-1)\tilde{V}_{\underline{SiC}}, \tag{25}$$

$$\Delta U = -\alpha_v T(P-1)\tilde{V}_{\underline{SiC}}, \tag{26}$$

are readily derived from the differential formulas relating the various thermodynamic functions. Each of the above terms must be multiplied by the factor c = 0.0242172 to convert it from cc-atmospheres to calories.

The specific volume of the mixture (in cubic centimeters per gram) is given by the expression

$$v = \frac{1}{40.097}\left\{nRT/P + n_{\underline{SiC}}\tilde{V}_{\underline{SiC}}\right\}, \tag{27}$$

where the first term in the braces is the volume of the gas phase and the second term is that of the condensed phase.

IV. BASIC DATA

The pertinent thermodynamic properties (heat content, entropy, free energy, and heat of formation) for this study were taken from three sources: JANAF Thermochemical Data,[1] Duff and Bauer,[2] and F. R. Gilmore.[3] The molecular weights and heats of formation of the various components are listed in the following table.

Species	Molecular Weight	Heat of Formation at 0°K (cal/mole)	Reference
SiC(β,s)	40.097	-17,261	1
SiC(g)	40.097	170,806	1
Si_2C	68.183	127,068	1
SiC_2	52.108	145,631	1
Si	28.086	106,664	1
Si_2	56.172	140,324	1
Si_3	84.258	151,219	1
C	12.011	169,576	1
C_2	24.022	197,000	1
C_3	36.033	188,104	1
C_4	48.044	240,500	1
C_5	60.055	240,298	1
C_6	72.066	287,000	2
C_7	84.077	287,000	2
C_8	96.088	339,000	2
C_9	108.099	334,000	2
C_{10}	120.110	393,000	2
e^-	0.0005489	0	1
C^-	12.0115	140,800	1
C_2^-	24.0225	125,500	1
C^+	12.0105	429,623	3
C^{+2}	12.0099	991,894	3
C^{+3}	12.0094	2,096,127	3
C^{+4}	12.0088	3,583,375	3
C^{+5}	12.0083	12,625,199	3
C^{+6}	12.0077	23,924,616	3

The molar volume of solid SiC ($\tilde{V}_{SiC}$ = 12.5 cc) was derived from a mean density of 3.21 gm/cc.

The volume coefficient of thermal expansion for silicon carbide is

$$\alpha_v = \frac{1}{v}\left[\frac{\partial v}{\partial T}\right]_p = 14.1 \times 10^{-6} \text{ cc/cc-deg.}$$

This value was derived from the linear coefficient of thermal expansion for silicon carbide given in Ref. 4 for the temperature range 20-800°C.

Two values of the gas constant were used: R = 1.98716 cal/deg-mole and R = 82.0557 cc-atm/deg-mole. Their ratio gives the conversion factor c = 0.0242172.

V. COMPUTATIONAL PROCEDURE

The two sets of equilibrium composition equations--the one involving condensed SiC and the other the gaseous species only--represent two mutually exclusive contiguous regions. It is expedient to determine the border line between the two regions, that is, the conditions of temperature and pressure under which the condensed species just vanishes. This can be done in the following manner.

Since $n_{\underline{SiC}} = 0$ along the gas/condensate interface, it follows that Eqs. (5) and (12) are identical for this condition. Hence, for a particular species, say SiC (g), combining Eqs. (5) and (12) gives the relation

$$n_{Si} n_C (P/n)^2 = (K^6_{SiC}/K^1_{SiC}) \exp\left[(P - 1)\bar{V}_{\underline{SiC}}/RT\right], \qquad (28)$$

where the equilibrium constants K^1_{SiC} and K^6_{SiC} are computed on the basis of Eqs. (1) and (6), respectively. Now, if each side of Eq. (28) is plotted against pressure for an arbitrary temperature, the result is a graph of two curves that intersect at a unique pressure.

VI. RESULTS

The results of this study are presented numerically in Tables 1 and 2 and graphically in Figs. 1 through 4. Figure 1--as well as its detail, Fig. 2--is a conventional Mollier diagram for silicon carbide; specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight in the pure gas region, and cross plots of temperature and moles of condensed SiC in the gas-solid region. The broken line demarcates the pure gas phase (above) from the smoke (below). The absence of a discontinuity at 3259°K (the temperature at which β-SiC is supposed to decompose at 1 atm) is due to the lack of experimental data concerning the solubility of graphite in liquid silicon at and above this temperature.

Figure 3 is a plot of volume versus temperature with cross plots of constant pressure and moles of condensed SiC.

The variation of sublimation temperature with pressure for silicon carbide and graphite is shown in Fig. 4. For silicon carbide at 10^{-3} atm the sublimation temperature is 2483°K, at 1 atm it is 3259°K, while at 10^{2} atm it is 4096°K. The corresponding temperatures for graphite are 3150°K, 4127°K, and 5170°K, respectively.[5]

All the computations required to obtain the results in Tables 1 and 2 were made on the RAND IBM 7040/7044 computer. In the tables the numbers are represented in "floating decimal" notation; the first five digits indicate the decimal form of the number, and the last two digits indicate a power of 10. Thus, 12345 05 represents 0.12345×10^{5} and 12345-05 represents 0.12345×10^{-5}.

Table 1

SUMMARY OF COMPUTED VALUES OF VOLUME, MOLECULAR WEIGHT, MOLES OF GAS, AND MOLES OF SOLID SiC FOR SILICON CARBIDE AT VARIOUS TEMPERATURES AND PRESSURES

Temperature T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
6000 04	10000-07	12565 02	13403 02	29916 01	
6000 04	10000-06	11555 02	13707 02	29252 01	
6000 04	10000-05	10508 02	15289 02	26225 01	
6000 04	10000-04	94425 01	17771 02	22563 01	
6000 04	10000-03	84085 01	19218 02	20864 01	
6000 04	10000-02	73962 01	19774 02	20278 01	
6000 04	10000-01	63920 01	19963 02	20085 01	
6000 04	10000 00	53901 01	20050 02	19998 01	
6000 04	10000 01	43841 01	20333 02	19720 01	
6000 04	10000 02	33370 01	22658 02	17696 01	
6000 04	10000 03	21832 01	32293 02	12417 01	
6000 04	10000 04	10454 01	44348 02	90414 00	
5500 04	10000-07	12519 02	13674 02	29323 01	
5500 04	10000-06	11473 02	15172 02	26429 01	
5500 04	10000-05	10407 02	17668 02	22694 01	
5500 04	10000-04	93718 01	19174 02	20912 01	
5500 04	10000-03	83587 01	19758 02	20294 01	
5500 04	10000-02	73544 01	19956 02	20092 01	
5500 04	10000-01	63528 01	20028 02	20021 01	
5500 04	10000 00	53507 01	20126 02	19923 01	
5500 04	10000 01	43342 01	20905 02	19180 01	
5500 04	10000 02	32335 01	26363 02	15210 01	
5500 04	10000 03	20774 01	37766 02	10617 01	
5500 04	10000 04	97013 00	48343 02	82942 00	
5000 04	10000-07	12423 02	15500 02	25848 01	
5000 04	10000-06	11359 02	17943 02	22347 01	
5000 04	10000-05	10328 02	19291 02	20786 01	
5000 04	10000-04	93164 01	19799 02	20252 01	
5000 04	10000-03	83127 01	19969 02	20080 01	
5000 04	10000-02	73115 01	20026 02	20022 01	
5000 04	10000-01	63105 01	20073 02	19976 01	
5000 04	10000 00	53040 01	20372 02	19682 01	
5000 04	10000 01	42494 01	23106 02	17354 01	
5000 04	10000 02	30968 01	32828 02	12214 01	
5000 04	10000 03	19801 01	42947 02	93363 00	

Table 1--continued

Temperature, T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
5000 04	10000 04	89569 00	52166 02	76864 00	
5000 04	30044 04	39355 00	55179 02	72668 00	-55879-08
5000 04	30044 04	35383 00	53179 02	65401 00	10000 00
5000 04	30044 04	31010 00	51318 02	58134 00	20000 00
5000 04	30044 04	26148 00	49584 02	50867 00	30000 00
5000 04	30044 04	20672 00	47963 02	43601 00	40000 00
5000 04	30044 04	14404 00	46444 02	36334 00	50000 00
5000 04	30044 04	70765-01	45019 02	29067 00	60000 00
5000 04	30044 04	-17431-01	43679 02	21800 00	70000 00
5000 04	30044 04	-12823 00	42416 02	14534 00	80000 00
5000 04	30044 04	-27734 00	41224 02	72668-01	90000 00
5000 04	30044 04	-47710 00	40207 02	72668-02	99000 00
5000 04	30044 04	-50323 00	40108 02	72668-03	99900 00
5000 04	30044 04	-50593 00	40098 02	72668-04	99990 00
5000 04	30044 04	-50620 00	40097 02	72668-05	99999 00
4500 04	10000-07	12298 02	18586 02	21574 01	
4500 04	10000-06	11276 02	19545 02	20515 01	
4500 04	10000-05	10269 02	19885 02	20164 01	
4500 04	10000-04	92664 01	19997 02	20052 01	
4500 04	10000-03	82656 01	20034 02	20015 01	
4500 04	10000-02	72650 01	20059 02	19989 01	
4500 04	10000-01	62617 01	20211 02	19840 01	
4500 04	10000 00	52294 01	21773 02	18416 01	
4500 04	10000 01	40937 01	29762 02	13473 01	
4500 04	10000 02	29729 01	39307 02	10201 01	
4500 04	10000 03	18845 01	48170 02	83240 00	
4500 04	51832 03	11209 01	53933 02	74346 00	-97789-08
4500 04	51832 03	10762 01	52134 02	66912 00	10000 00
4500 04	51832 03	10265 01	50451 02	59477 00	20000 00
4500 04	51832 03	97034 00	48874 02	52042 00	30000 00
4500 04	51832 03	90580 00	47392 02	44608 00	40000 00
4500 04	51832 03	82997 00	45997 02	37173 00	50000 00
4500 04	51832 03	73804 00	44682 02	29739 00	60000 00
4500 04	51832 03	62127 00	43440 02	22304 00	70000 00
4500 04	51832 03	46107 00	42266 02	14869 00	80000 00
4500 04	51832 03	20451 00	41153 02	74346-01	90000 00
4500 04	51832 03	-35586 00	40200 02	74346-02	99000 00
4500 04	51832 03	-48863 00	40107 02	74346-03	99900 00
4500 04	51832 03	-50444 00	40098 02	74346-04	99990 00
4500 04	51832 03	-50605 00	40097 02	74346-05	99999 00

Table 1--continued

Temperature, T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
4000 04	10000-07	12219 02	19820 02	20231 01	
4000 04	10000-06	11216 02	19975 02	20073 01	
4000 04	10000-05	10215 02	20025 02	20023 01	
4000 04	10000-04	92142 01	20042 02	20006 01	
4000 04	10000-03	82139 01	20058 02	19990 01	
4000 04	10000-02	72114 01	20173 02	19877 01	
4000 04	10000-01	61840 01	21486 02	18662 01	
4000 04	10000 00	50549 01	28926 02	13862 01	
4000 04	10000 01	39380 01	37863 02	10590 01	
4000 04	10000 02	28624 01	45054 02	88997 00	
4000 04	64751 02	19870 01	52230 02	76771 00	-12340-07
4000 04	64751 02	19414 01	50696 02	69094 00	10000 00
4000 04	64751 02	18904 01	49249 02	61416 00	20000 00
4000 04	64751 02	18327 01	47883 02	53739 00	30000 00
4000 04	64751 02	17661 01	46591 02	46062 00	40000 00
4000 04	64751 02	16874 01	45366 02	38385 00	50000 00
4000 04	64751 02	15912 01	44205 02	30708 00	60000 00
4000 04	64751 02	14674 01	43101 02	23031 00	70000 00
4000 04	64751 02	12936 01	42051 02	15354 00	80000 00
4000 04	64751 02	99938 00	41051 02	76771-01	90000 00
4000 04	64751 02	10691 00	40191 02	76771-02	99000 00
4000 04	64751 02	-38885 00	40106 02	76771-03	99900 00
4000 04	64751 02	-49296 00	40098 02	76771-04	99990 00
4000 04	64751 02	-50489 00	40097 02	76771-05	99999 00
3500 04	10000-07	12157 02	20029 02	20019 01	
3500 04	10000-06	11156 02	20043 02	20006 01	
3500 04	10000-05	10156 02	20048 02	20000 01	
3500 04	10000-04	91558 01	20064 02	19984 01	
3500 04	10000-03	81522 01	20228 02	19822 01	
3500 04	10000-02	71084 01	22374 02	17922 01	
3500 04	10000-01	59701 01	30768 02	13032 01	
3500 04	10000 00	48752 01	38278 02	10475 01	
3500 04	10000 01	38162 01	43849 02	91443 00	
3500 04	46702 01	30929 01	49649 02	80761 00	-73342-08
3500 04	46702 01	30472 01	48494 02	72685 00	10000 00
3500 04	46702 01	29960 01	47391 02	64609 00	20000 00
3500 04	46702 01	29381 01	46338 02	56533 00	30000 00
3500 04	46702 01	28712 01	45330 02	48457 00	40000 00
3500 04	46702 01	27920 01	44365 02	40381 00	50000 00
3500 04	46702 01	26952 01	43440 02	32304 00	60000 00
3500 04	46702 01	25703 01	42553 02	24228 00	70000 00

Table 1--continued

Temperature, T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
3500 04	46702 01	23944 01	41702 02	16152 00	80000 00
3500 04	46702 01	20939 01	40884 02	80761-01	90000 00
3500 04	46702 01	11036 01	40174 02	80761-02	99000 00
3500 04	46702 01	19033 00	40105 02	80761-03	99900 00
3500 04	46702 01	-36096 00	40098 02	80761-04	99990 00
3500 04	46702 01	-48932 00	40097 02	80761-05	99999 00
3259 04	99866 00	37461 01	48051 02	83447 00	-25029-08
3259 04	99866 00	37003 01	47116 02	75102 00	10000 00
3259 04	99866 00	36492 01	46217 02	66758 00	20000 00
3259 04	99866 00	35912 01	45352 02	58413 00	30000 00
3259 04	99866 00	35242 01	44519 02	50068 00	40000 00
3259 04	99866 00	34451 01	43715 02	41724 00	50000 00
3259 04	99866 00	33482 01	42940 02	33379 00	60000 00
3259 04	99866 00	32233 01	42192 02	25034 00	70000 00
3259 04	99866 00	30472 01	41470 02	16689 00	80000 00
3259 04	99866 00	27463 01	40772 02	83447-01	90000 00
3259 04	99866 00	17485 01	40164 02	83447-02	99000 00
3259 04	99866 00	76969 00	40104 02	83447-03	99900 00
3259 04	99866 00	-60995-01	40098 02	83447-04	99990 00
3259 04	99866 00	-43481 00	40097 02	83447-05	99999 00
3000 04	10000-07	12089 02	20048 02	20000 01	
3000 04	10000-06	11089 02	20054 02	19995 01	
3000 04	10000-05	10088 02	20105 02	19943 01	
3000 04	10000-04	90706 01	20925 02	19162 01	
3000 04	10000-03	79586 01	27078 02	14808 01	
3000 04	10000-02	68452 01	35158 02	11405 01	
3000 04	10000-01	57909 01	39846 02	10063 01	
3000 04	10000 00	47399 01	44808 02	89487 00	
3000 04	14625 00	45619 01	46156 02	86873 00	-10026-07
3000 04	14625 00	45162 01	45469 02	78186 00	10000 00
3000 04	14625 00	44650 01	44802 02	69498 00	20000 00
3000 04	14625 00	44070 01	44155 02	60811 00	30000 00
3000 04	14625 00	43401 01	43525 02	52124 00	40000 00
3000 04	14625 00	42609 01	42914 02	43436 00	50000 00
3000 04	14625 00	41640 01	42319 02	34749 00	60000 00
3000 04	14625 00	40390 01	41741 02	26062 00	70000 00
3000 04	14625 00	38630 01	41178 02	17375 00	80000 00
3000 04	14625 00	35619 01	40631 02	86873-01	90000 00
3000 04	14625 00	25623 01	40150 02	86873-02	99000 00
3000 04	14625 00	15656 01	40102 02	86873-03	99900 00
3000 04	14625 00	59753 00	40098 02	86873-04	99990 00
3000 04	14625 00	-16980 00	40097 02	86873-05	99999 00

Table 1--continued

Temperature, T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
2500 04	10000-07	12008 02	20143 02	19906 01	
2500 04	10000-06	10968 02	22064 02	18173 01	
2500 04	10000-05	98487 01	29063 02	13796 01	
2500 04	10000-04	87606 01	35598 02	11264 01	
2500 04	10000-03	77160 01	39451 02	10164 01	
2500 04	10000-02	66864 01	42230 02	94950 00	
2500 04	12127-02	65985 01	42636 02	94044 00	-14584-07
2500 04	12127-02	65527 01	42368 02	84640 00	10000 00
2500 04	12127-02	65016 01	42103 02	75235 00	20000 00
2500 04	12127-02	64436 01	41842 02	65831 00	30000 00
2500 04	12127-02	63767 01	41583 02	56427 00	40000 00
2500 04	12127-02	62975 01	41328 02	47022 00	50000 00
2500 04	12127-02	62006 01	41076 02	37618 00	60000 00
2500 04	12127-02	60756 01	40827 02	28213 00	70000 00
2500 04	12127-02	58995 01	40581 02	18809 00	80000 00
2500 04	12127-02	55985 01	40337 02	94044-01	90000 00
2500 04	12127-02	45985 01	40121 02	94044-02	99000 00
2500 04	12127-02	35985 01	40100 02	94044-03	99900 00
2500 04	12127-02	25988 01	40097 02	94044-04	99990 00
2500 04	12127-02	16019 01	40097 02	94044-05	99999 00
2200 04	24596-04	82513 01	41150 02	97442 00	-10746-07
2200 04	24596-04	82055 01	41042 02	87698 00	10000 00
2200 04	24596-04	81544 01	40935 02	77954 00	20000 00
2200 04	24596-04	80964 01	40828 02	68210 00	30000 00
2200 04	24596-04	80295 01	40722 02	58465 00	40000 00
2200 04	24596-04	79503 01	40617 02	48721 00	50000 00
2200 04	24596-04	78534 01	40512 02	38977 00	60000 00
2200 04	24596-04	77284 01	40407 02	29233 00	70000 00
2200 04	24596-04	75523 01	40303 02	19488 00	80000 00
2200 04	24596-04	72513 01	40200 02	97442-01	90000 00
2200 04	24596-04	62513 01	40107 02	97442-02	99000 00
2200 04	24596-04	52513 01	40098 02	97442-03	99900 00
2200 04	24596-04	42513 01	40097 02	97442-04	99990 00
2200 04	24596-04	32514 01	40097 02	97442-05	99999 00
2000 04	10000-07	11663 02	35623 02	11256 01	
2000 04	10000-06	10623 02	39137 02	10245 01	
2000 04	95826-06	96259 01	40526 02	98942 00	-16809-07
2000 04	95826-06	95802 01	40483 02	89048 00	10000 00
2000 04	95826-06	95290 01	40439 02	79153 00	20000 00
2000 04	95826-06	94710 01	40396 02	69259 00	30000 00
2000 04	95826-06	94041 01	40353 02	59365 00	40000 00

Table 1--continued

Temperature, T (°K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas, n	Moles of SiC
2000 04	95826-06	93249 01	40310 02	49471 00	50000 00
2000 04	95826-06	92280 01	40268 02	39577 00	60000 00
2000 04	95826-06	91030 01	40225 02	29683 00	70000 00
2000 04	95826-06	89270 01	40182 02	19788 00	80000 00
2000 04	95826-06	86259 01	40140 02	98942-01	90000 00
2000 04	95826-06	76259 01	40101 02	98942-02	99000 00
2000 04	95826-06	66259 01	40098 02	98942-03	99900 00
2000 04	95826-06	56259 01	40097 02	98942-04	99990 00
2000 04	95826-06	46259 01	40097 02	98942-05	99999 00
1700 04	17355-08	12303 02	40023 02	10019 01	55760-08
1700 04	17355-08	12257 02	40030 02	90167 00	10000 00
1700 04	17355-08	12206 02	40038 02	80148 00	20000 00
1700 04	17355-08	12148 02	40045 02	70130 00	30000 00
1700 04	17355-08	12081 02	40053 02	60111 00	40000 00
1700 04	17355-08	12002 02	40060 02	50093 00	50000 00
1700 04	17355-08	11905 02	40067 02	40074 00	60000 00
1700 04	17355-08	11780 02	40075 02	30056 00	70000 00
1700 04	17355-08	11604 02	40082 02	20037 00	80000 00
1700 04	17355-08	11303 02	40090 02	10018 00	90000 00
1700 04	17355-08	10303 02	40096 02	10019-01	99000 00
1700 04	17355-08	93028 01	40097 02	10019-02	99900 00
1700 04	17355-08	83028 01	40097 02	10019-03	99990 00
1700 04	17355-08	73028 01	40097 02	10019-04	99999 00
1774 04	10000-07	11560 02	40136 02	99928 00	
1882 04	10000-06	10583 02	40293 02	99531 00	
2002 04	10000-05	96079 01	40532 02	98928 00	
2140 04	10000-04	86326 01	40932 02	97957 00	
2299 04	10000-03	76569 01	41573 02	96440 00	
2483 04	10000-02	66804 01	42538 02	94259 00	
2698 04	10000-01	57021 01	43959 02	91213 00	
2953 04	10000 00	47234 01	45810 02	87529 00	
3259 04	10000 01	37455 01	48053 02	83444 00	
3632 04	10000 02	27716 01	50430 02	79510 00	
4096 04	10000 03	18054 01	52611 02	76215 00	
4678 04	10000 04	84855 00	54416 02	73687 00	

Table 2

SUMMARY OF COMPUTED VALUES OF DENSITY, ENTHALPY, ENERGY, AND ENTROPY FOR SILICON CARBIDE AT VARIOUS TEMPERATURES AND PRESSURES

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
6CCO 04	1CCCC-C7	27224-12	15612 05	14722 05	60744 01
6CCO 04	1CCCO-C6	27841-11	15134 05	14264 05	56560 01
6COO 04	1COOO-C5	31055-10	12956 05	12176 05	49737 01
6COC 04	1CCCC-C4	36096-09	10321 05	96500 04	42577 01
6COO 04	1COOO-03	39035-08	90984 04	84780 04	38078 01
6CCO 04	1CCCO-C2	40164-07	86766 04	80737 04	35034 01
6COO 04	1COOO-C1	40548-06	85393 04	79421 04	32504 01
6CCO C4	1CCCC CC	40724-05	84865 04	78919 04	30129 01
6CCO 04	1CCCO C1	41299-04	83813 04	77949 04	27682 01
6CCO 04	1COCC C2	46022-03	76518 04	71256 04	24299 01
6COO 04	1CCOO C3	65591-02	57415 04	53722 04	19390 01
6CCO C4	1CCCC 04	9C077-01	46268 04	43579 04	16332 01
55CO 04	1CCOO-C7	3C299-12	14996 05	14196 05	59661 01
55OO 04	1COOO-06	33618-11	12929 05	12209 05	52694 01
55CO 04	1COCO-05	39149-10	10263 05	96442 04	45058 01
55CO 04	1CCCO-04	42486-09	89903 04	84203 04	40273 01
55CO 04	1CCCO-C3	43781-08	85487 04	79955 04	37126 01
55OO 04	1COCO-02	44219-07	84054 04	78577 04	34563 01
55CC 04	1CCCC-C1	44377-06	83571 04	78113 04	32187 01
55CO 04	1CCOO CC	44596-05	83149 04	77718 04	29830 01
55CO 04	1CCOO C1	46321-04	80461 C4	75233 04	27096 01
55OO 04	1CCOO 02	58414-03	65831 04	61685 04	22432 01
55CO 04	1CCCC 03	83680-02	49368 04	46474 04	17993 01
55CO 04	1COCO 04	1C712 00	42284 04	40024 04	15640 01
5COO 04	1CCCO-C7	37780-12	12359 05	11718 05	54591 01
5CCO 04	1CCOO-C6	43733-11	98647 04	93110 04	46869 01
5CCO C4	1CCCC-C5	47019-10	87583 04	82432 04	42210 01
5CCO 04	1CCCC-C4	48257-C9	83804 04	78786 04	39118 01
5COO 04	1COOO-03	48671-08	82584 04	77608 04	36575 01
5CCO 04	1COCC-02	48811-07	82186 04	77224 04	34208 01
5CCO 04	1CCOO-01	48925-06	81959 04	77010 04	31880 01
5CCO 04	1CCCO OC	49654-05	80885 04	76008 04	29397 01
5CCO 04	1COCO 01	56317-04	72261 04	67961 04	25521 01
5CCC 04	1CCCC 02	8C015-03	53104 04	50077 04	20009 01
5CCO 04	1CCCO 03	10468-C1	43477 04	41164 04	16873 01

Table 2--continued

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
5000 04	10000 04	12715 00	38835 04	36931 04	14983 01
5000 04	30044 04	40407 00	37654 04	35853 04	14340 01
5000 04	30044 04	44277 00	34984 04	33341 04	13806 01
5000 04	30044 04	48966 00	32315 04	30830 04	13272 01
5000 04	30044 04	54767 00	29646 04	28318 04	12739 01
5000 04	30044 04	62127 00	26977 04	25806 04	12205 01
5000 04	30044 04	71773 00	24308 04	23295 04	11671 01
5000 04	30044 04	84964 00	21639 04	20783 04	11137 01
5000 04	30044 04	10410 01	18970 04	18271 04	10603 01
5000 04	30044 04	13435 01	16301 04	15760 04	10070 01
5000 04	30044 04	18938 01	13632 04	13248 04	95357 00
5000 04	30044 04	29998 01	11230 04	10987 04	90553 00
5000 04	30044 04	31859 01	10990 04	10761 04	90073 00
5000 04	30044 04	32058 01	10966 04	10739 04	90025 00
5000 04	30044 04	32078 01	10963 04	10737 04	90020 00
4500 04	10000-07	50335-12	91710 04	86899 04	47913 01
4500 04	10000-06	52933-11	84268 04	79693 04	43868 01
4500 04	10000-05	53853-10	81805 04	77308 04	41004 01
4500 04	10000-04	54154-09	81016 04	76544 04	38535 01
4500 04	10000-03	54255-08	80760 04	76296 04	36192 01
4500 04	10000-02	54324-07	80629 04	76171 04	33880 01
4500 04	10000-01	54734-06	80077 04	75653 04	31492 01
4500 04	10000 00	58966-05	74787 04	70680 04	28097 01
4500 04	10000 01	80601-04	56045 04	53040 04	22097 01
4500 04	10000 02	10645-02	44298 04	42023 04	18163 01
4500 04	10000 03	13045-01	38867 04	37011 04	15903 01
4500 04	51832 03	75706-01	36445 04	34787 04	14726 01
4500 04	51832 03	83898-01	33708 04	32212 04	14117 01
4500 04	51832 03	94078-01	30971 04	29637 04	13509 01
4500 04	51832 03	10707 00	28234 04	27062 04	12901 01
4500 04	51832 03	12422 00	25497 04	24487 04	12293 01
4500 04	51832 03	14792 00	22761 04	21912 04	11685 01
4500 04	51832 03	18280 00	20024 04	19337 04	11076 01
4500 04	51832 03	23918 00	17287 04	16762 04	10468 01
4500 04	51832 03	34588 00	14550 04	14187 04	98601 00
4500 04	51832 03	62444 00	11813 04	11612 04	92519 00
4500 04	51832 03	22692 01	93501 03	92948 03	87045 00
4500 04	51832 03	30805 01	91038 03	90630 03	86498 00
4500 04	51832 03	31948 01	90791 03	90399 03	86443 00
4500 04	51832 03	32067 01	90767 03	90375 03	86438 00

Table 2--continued

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
4000 04	10000-07	60385-12	80899 04	76889 04	45400 01
4000 04	10000-06	60859-11	79801 04	75822 04	42827 01
4000 04	10000-05	61012-10	79452 04	75483 04	40453 01
4000 04	10000-04	61063-09	79337 04	75371 04	38140 01
4000 04	10000-03	61112-08	79263 04	75301 04	35840 01
4000 04	10000-02	61460-07	78847 04	74907 04	33459 01
4000 04	10000-01	65462-06	74292 04	70592 04	30096 01
4000 04	10000 00	88130-05	55888 04	53140 04	23620 01
4000 04	10000 01	11536-03	43838 04	41739 04	19242 01
4000 04	10000 02	13727-02	38743 04	36978 04	16857 01
4000 04	64751 02	10304-01	35456 04	33934 04	15272 01
4000 04	64751 02	11445-01	32645 04	31274 04	14569 01
4000 04	64751 02	12869-01	29833 04	28615 04	13866 01
4000 04	64751 02	14699-01	27022 04	25955 04	13163 01
4000 04	64751 02	17136-01	24210 04	23295 04	12460 01
4000 04	64751 02	20542-01	21399 04	20636 04	11757 01
4000 04	64751 02	25636-01	18588 04	17976 04	11055 01
4000 04	64751 02	34090-01	15776 04	15316 04	10352 01
4000 04	64751 02	50865-01	12965 04	12657 04	96489 00
4000 04	64751 02	10014 00	10153 04	99968 03	89460 00
4000 04	64751 02	78178 00	76231 03	76031 03	83134 00
4000 04	64751 02	24482 01	73701 03	73637 03	82502 00
4000 04	64751 02	31114 01	73448 03	73397 03	82439 00
4000 04	64751 02	31981 01	73423 03	73373 03	82432 00
3500 04	10000-07	69742-12	78073 04	74601 04	44654 01
3500 04	10000-06	69788-11	77983 04	74512 04	42344 01
3500 04	10000-05	69807-10	77949 04	74480 04	40052 01
3500 04	10000-04	69863-09	77887 04	74420 04	37753 01
3500 04	10000-03	70434-08	77291 04	73853 04	35308 01
3500 04	10000-02	77904-07	70010 04	66902 04	31037 01
3500 04	10000-01	10713-05	51148 04	48887 04	23887 01
3500 04	10000 00	13378-04	41812 04	39995 04	19903 01
3500 04	10000 01	15268-03	37811 04	36225 04	17639 01
3500 04	46702 01	80736-03	34944 04	33543 04	16162 01
3500 04	46702 01	89704-03	32015 04	30754 04	15325 01
3500 04	46702 01	10091-02	29085 04	27964 04	14488 01
3500 04	46702 01	11533-02	26155 04	25175 04	13651 01
3500 04	46702 01	13454-02	23226 04	22385 04	12814 01
3500 04	46702 01	16143-02	20296 04	19596 04	11977 01
3500 04	46702 01	20176-02	17367 04	16806 04	11140 01
3500 04	46702 01	26896-02	14437 04	14017 04	10303 01

Table 2--continued

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
3500 04	46702 01	40328-02	11508 04	11227 04	94661 00
3500 04	46702 01	80554-02	85783 03	84379 03	86291 00
3500 04	46702 01	78774-01	59417 03	59274 03	78758 00
3500 04	46702 01	64516 00	56781 03	56763 03	78004 00
3500 04	46702 01	22959 01	56517 03	56512 03	77929 00
3500 04	46702 01	30854 01	56491 03	56487 03	77922 00
3259 04	99866 00	17944-03	34937 04	33589 04	16788 01
3259 04	99866 00	19938-03	31927 04	30714 04	15864 01
3259 04	99866 00	22430-03	28917 04	27839 04	14941 01
3259 04	99866 00	25634-03	25908 04	24964 04	14017 01
3259 04	99866 00	29906-03	22898 04	22089 04	13094 01
3259 04	99866 00	35887-03	19888 04	19214 04	12170 01
3259 04	99866 00	44857-03	16879 04	16339 04	11247 01
3259 04	99866 00	59807-03	13869 04	13465 04	10323 01
3259 04	99866 00	89701-03	10859 04	10590 04	93997 00
3259 04	99866 00	17935-02	78495 03	77146 03	84762 00
3259 04	99866 00	17845-01	51407 03	51272 03	76450 00
3259 04	99866 00	16995 00	48698 03	48684 03	75619 00
3259 04	99866 00	11508 01	48428 03	48425 03	75536 00
3259 04	99866 00	27215 01	48400 03	48400 03	75527 00
3000 04	10000-07	81442-12	76611 04	73637 04	44204 01
3000 04	10000-06	81463-11	76590 04	73618 04	41915 01
3000 04	10000-05	81674-10	76401 04	73436 04	39572 01
3000 04	10000-04	85003-09	73411 04	70562 04	36326 01
3000 04	10000-03	11000-07	56360 04	54158 04	28679 01
3000 04	10000-02	14282-06	43576 04	41880 04	22947 01
3000 04	10000-01	16186-05	38942 04	37446 04	20190 01
3000 04	10000 00	18202-04	35808 04	34478 04	18053 01
3000 04	14625 00	27421-04	35105 04	33814 04	17653 01
3000 04	14625 00	30468-04	31992 04	30830 04	16615 01
3000 04	14625 00	34277-04	28880 04	27846 04	15578 01
3000 04	14625 00	39173-04	25767 04	24862 04	14540 01
3000 04	14625 00	45702-04	22654 04	21879 04	13502 01
3000 04	14625 00	54842-04	19541 04	18895 04	12465 01
3000 04	14625 00	68552-04	16428 04	15911 04	11427 01
3000 04	14625 00	91403-04	13315 04	12927 04	10390 01
3000 04	14625 00	13710-03	10202 04	99436 03	93519 00
3000 04	14625 00	27419-03	70890 03	69598 03	83142 00
3000 04	14625 00	27398-02	42873 03	42744 03	73803 00
3000 04	14625 00	27189-01	40072 03	40059 03	72870 00
3000 04	14625 00	25262 00	39791 03	39790 03	72776 00
3000 04	14625 00	14784 01	39763 03	39763 03	72767 00

Table 2--continued

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
2500 04	10000-07	98193-12	74942 04	72476 04	43588 01
2500 04	10000-06	10756-10	69100 04	65848 04	38639 01
2500 04	10000-05	14168-09	50870 04	49161 04	29935 01
2500 04	10000-04	17353-08	41610 04	40215 04	24817 01
2500 04	10000-03	19231-07	37863 04	36604 04	22106 01
2500 04	10000-02	20586-06	35925 04	34749 04	20205 01
2500 04	12127-02	25205-06	35679 04	34514 04	20017 01
2500 04	12127-02	28006-06	32344 04	31295 04	18682 01
2500 04	12127-02	31507-06	29008 04	28076 04	17348 01
2500 04	12127-02	36008-06	25673 04	24857 04	16014 01
2500 04	12127-02	42009-06	22337 04	21638 04	14680 01
2500 04	12127-02	50411-06	19002 04	18419 04	13346 01
2500 04	12127-02	63014-06	15667 04	15200 04	12011 01
2500 04	12127-02	84018-06	12331 04	11982 04	10677 01
2500 04	12127-02	12603-05	89957 03	87626 03	93431 00
2500 04	12127-02	25205-05	56602 03	55437 03	80090 00
2500 04	12127-02	25205-04	26583 03	26467 03	68082 00
2500 04	12127-02	25204-03	23581 03	23570 03	66881 00
2500 04	12127-02	25186-02	23281 03	23280 03	66761 00
2500 04	12127-02	25009-01	23251 03	23251 03	66749 00
2200 04	24596-04	56066-08	35828 04	34766 04	21931 01
2200 04	24596-04	62296-08	32380 04	31424 04	20364 01
2200 04	24596-04	70082-08	28932 04	28082 04	18797 01
2200 04	24596-04	80094-08	25484 04	24740 04	17229 01
2200 04	24596-04	93443-08	22036 04	21398 04	15662 01
2200 04	24596-04	11213-07	18588 04	18057 04	14095 01
2200 04	24596-04	14016-07	15140 04	14715 04	12528 01
2200 04	24596-04	18689-07	11692 04	11373 04	10960 01
2200 04	24596-04	28033-07	82436 03	80311 03	93929 00
2200 04	24596-04	56066-07	47955 03	46892 03	78256 00
2200 04	24596-04	56066-06	16922 03	16816 03	64150 00
2200 04	24596-04	56066-05	13819 03	13808 03	62740 00
2200 04	24596-04	56065-04	13509 03	13507 03	62599 00
2200 04	24596-04	56056-03	13477 03	13477 03	62585 00
2000 04	10000-07	21707-11	40186 04	39071 04	28036 01
2000 04	10000-06	23848-10	36819 04	35804 04	25136 01
2000 04	95826-06	23664-09	35733 04	34753 04	23466 01
2000 04	95826-06	26293-09	32230 04	31348 04	21715 01
2000 04	95826-06	29579-09	28727 04	27943 04	19963 01
2000 04	95826-06	33805-09	25224 04	24538 04	18212 01
2000 04	95826-06	39439-09	21721 04	21133 04	16460 01

Table 2--continued

Temperature, T (°K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/deg-gm)
2000 04	95826-06	47327-09	18218 04	17728 04	14709 01
2000 04	95826-06	59159-09	14715 04	14323 04	12957 01
2000 04	95826-06	78878-09	11212 04	10918 04	11206 01
2000 04	95826-06	11832-08	77091 03	75129 03	94541 00
2000 04	95826-06	23664-08	42060 03	41080 03	77026 00
2000 04	95826-06	23664-07	10533 03	10435 03	61262 00
2000 04	95826-06	23664-06	73800 02	73702 02	59686 00
2000 04	95826-06	23663-05	70647 02	70637 02	59528 00
2000 04	95826-06	23663-04	70332 02	70331 02	59512 00
1700 04	17355-08	49793-12	35338 04	34494 04	26369 01
1700 04	17355-08	55326-12	31779 04	31019 04	24275 01
1700 04	17355-08	62241-12	28220 04	27545 04	22182 01
1700 04	17355-08	71133-12	24661 04	24070 04	20089 01
1700 04	17355-08	82989-12	21102 04	20596 04	17995 01
1700 04	17355-08	99586-12	17543 04	17121 04	15902 01
1700 04	17355-08	12448-11	13985 04	13647 04	13808 01
1700 04	17355-08	16598-11	10426 04	10173 04	11715 01
1700 04	17355-08	24897-11	68669 03	66981 03	96214 00
1700 04	17355-08	49793-11	33081 03	32237 03	75280 00
1700 04	17355-08	49793-10	10517 02	96727 01	56439 00
1700 04	17355-08	49793-09	-21513 02	-21597 02	54555 00
1700 04	17355-08	49793-08	-24716 02	-24724 02	54366 00
1700 04	17355-08	49793-07	-25036 02	-25037 02	54348 00
1774 04	10000-07	27569-11	35448 04	34570 04	25570 01
1882 04	10000-06	26102-10	35601 04	34674 04	24513 01
2002 04	10000-05	24669-09	35735 04	34754 04	23446 01
2140 04	10000-04	23303-08	35817 04	34778 04	22361 01
2299 04	10000-03	22034-07	35807 04	34709 04	21248 01
2483 04	10000-02	20875-06	35693 04	34533 04	20113 01
2698 04	10000-01	19854-05	35438 04	34219 04	18957 01
2953 04	10000 00	18904-04	35149 04	33869 04	17832 01
3259 04	10000 01	17968-03	34937 04	33588 04	16787 01
3632 04	10000 02	16920-02	35019 04	33587 04	15880 01
4096 04	10000 03	15653-01	35620 04	34073 04	15148 01
4678 04	10000 04	14173 00	36859 04	35151 04	14575 01

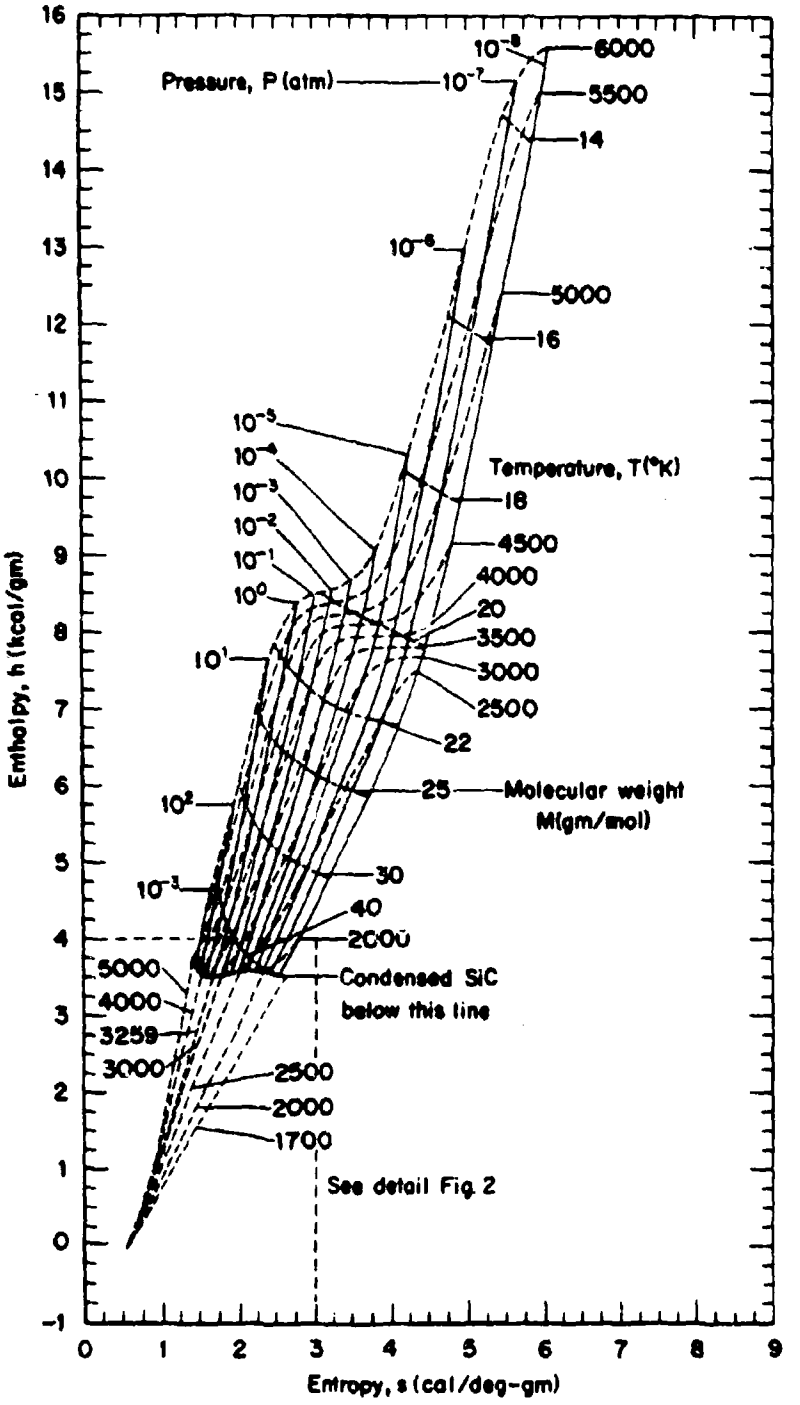

Fig. 1— Enthalpy versus entropy for silicon carbide with cross plots of temperature, pressure, molecular weight, and moles of condensed SiC

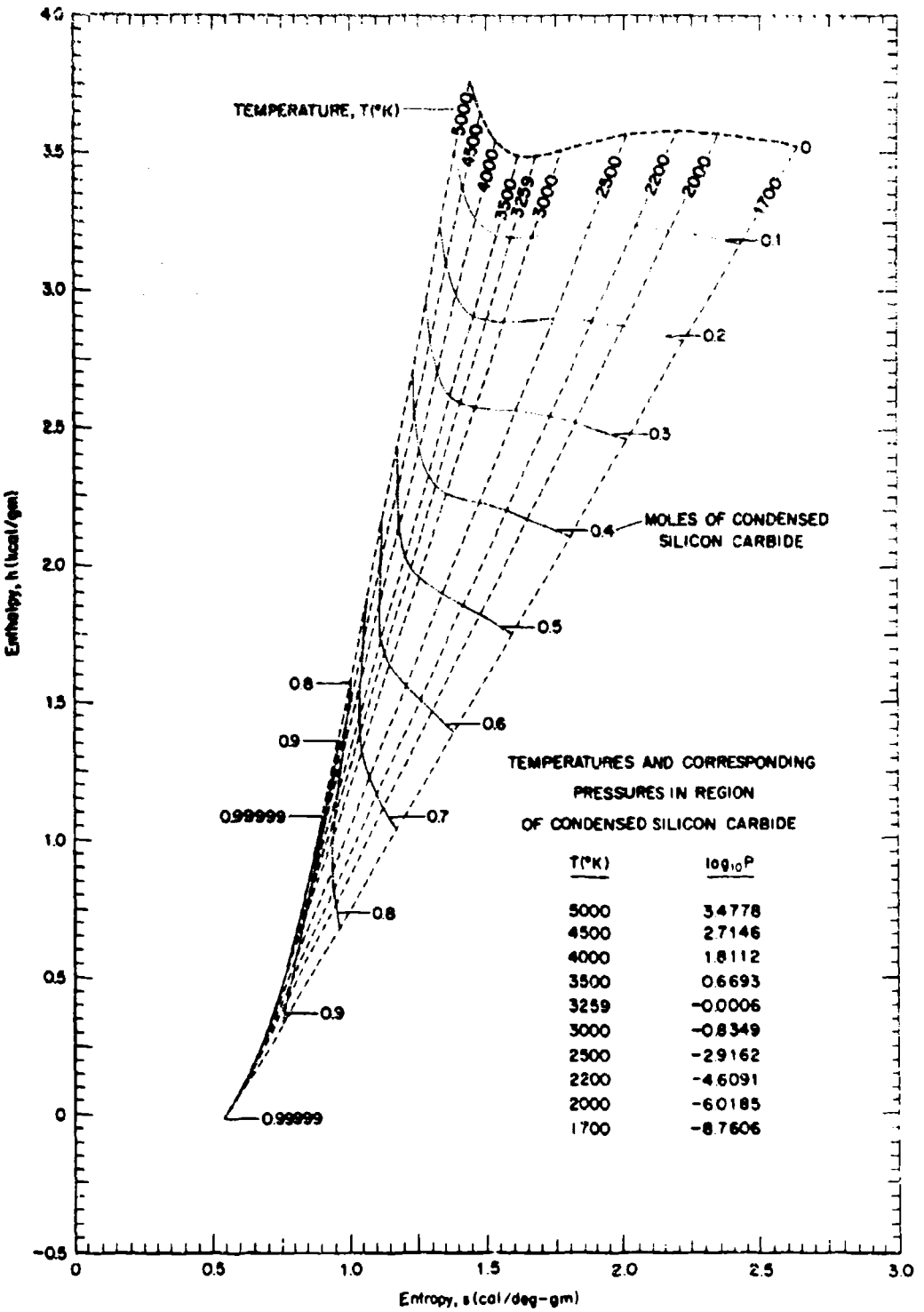

Fig. 2--Detail of Fig. 1 showing fine structure in area of condensed SiC

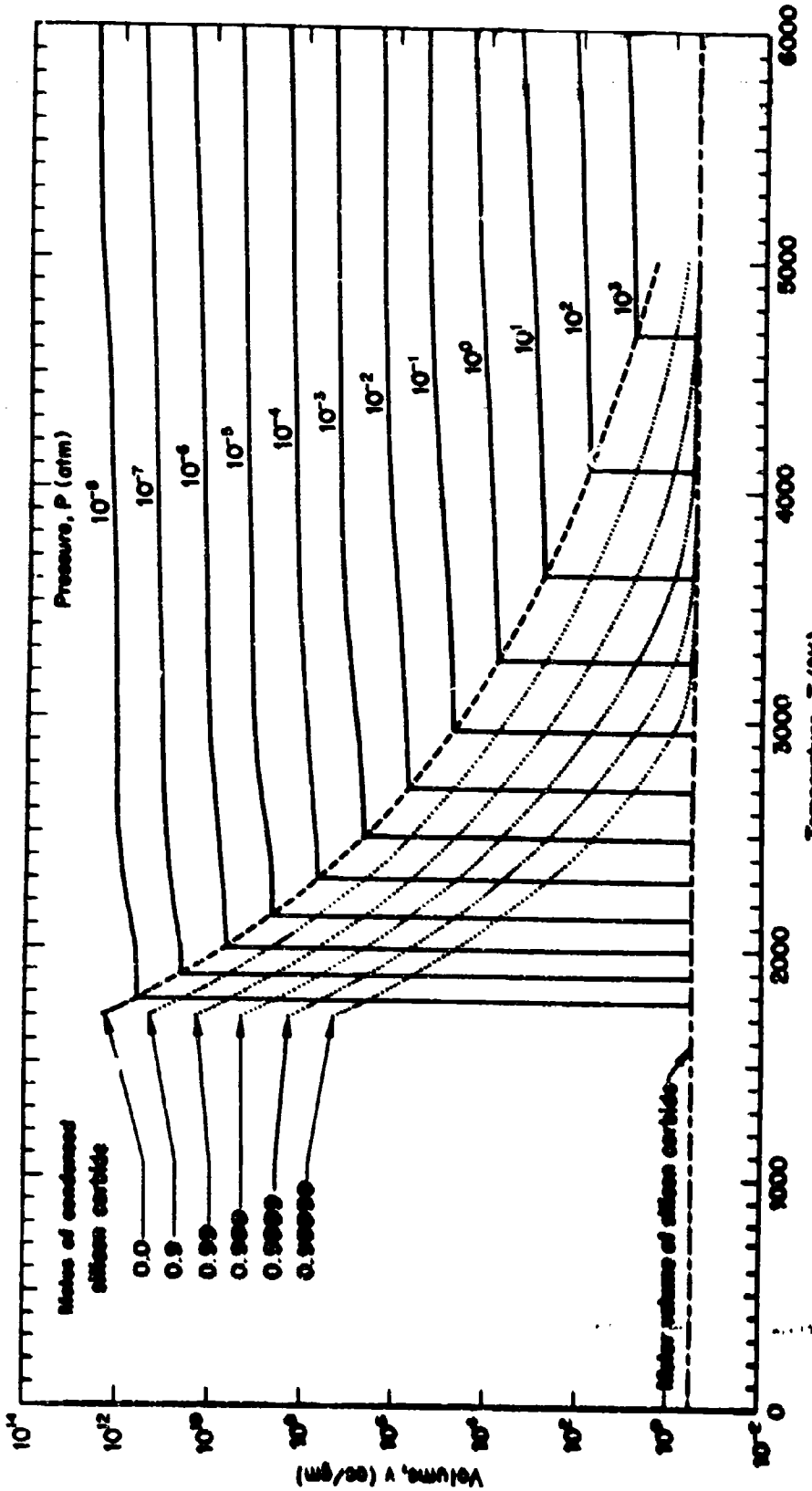

Fig. 3—Volume versus temperature for silicon carbide with cross plots of constant pressure and moles of condensed SiC

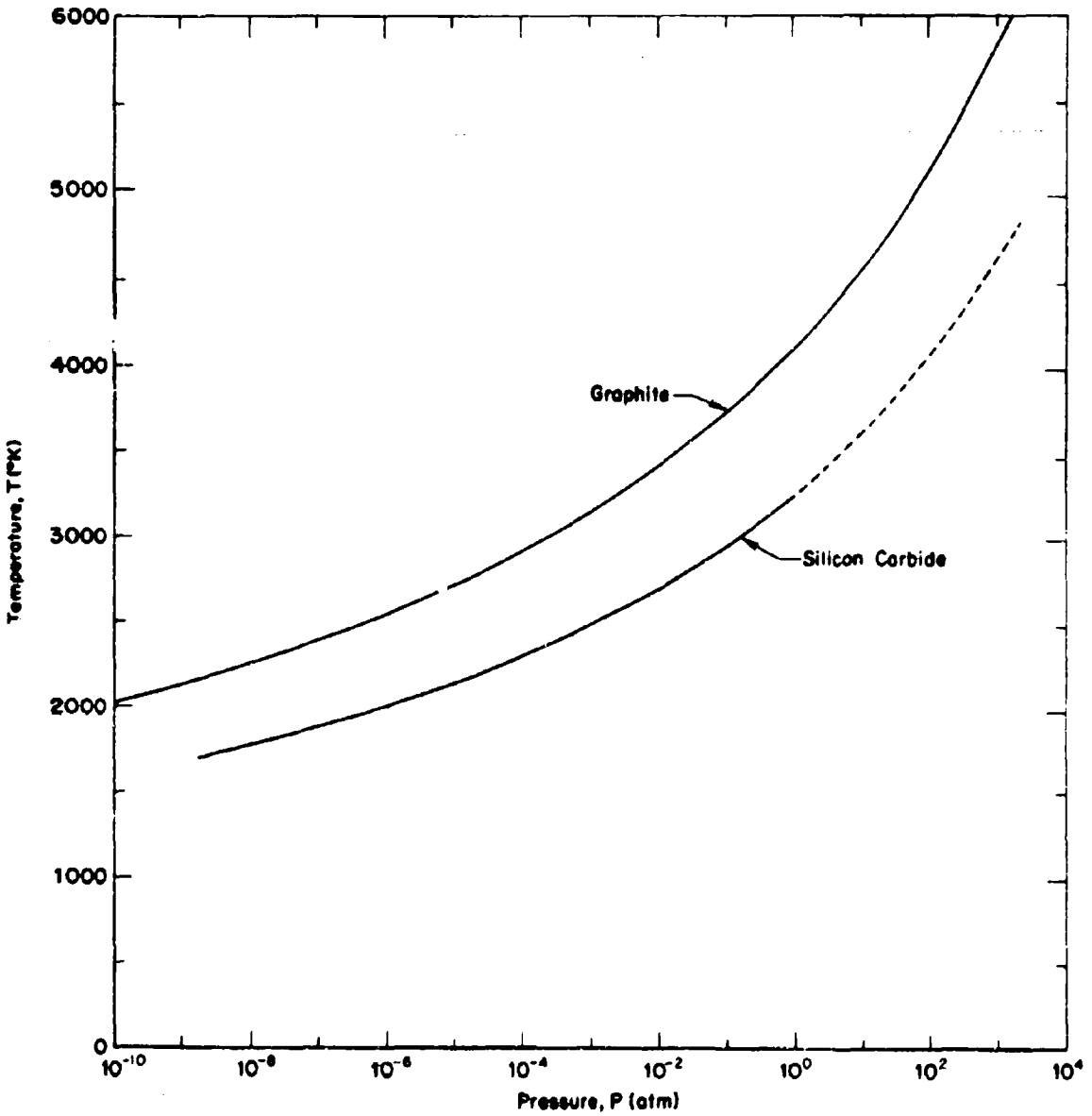

Fig. 4—Sublimation temperature for silicon carbide and graphite at various pressures

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10. ABSTRACT

An investigation of the thermodynamic properties of silicon carbide (SiC) over a range of temperatures up to 6000°K and pressures up to 1000 atmospheres. Two sets of equilibrium composition equations are used--one representing a pure gas phase, the other a heterogeneous system of gas and condensed (solid) silicon carbide. The gas phase of the heterogeneous chemical system, like the homogeneous gas phase, comprises 25 gaseous silicon-carbide species. Tabulated summaries give computed values of volume, molecular weight, moles of gas, moles of solid SiC, density, enthalpy, energy, and entropy for silicon carbide at various temperatures and pressures. A conventional Mollier diagram is included in which specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight in the pure gas region, and cross plots of temperature and moles of condensed SiC in the gas-solid region. Variation of sublimination temperature with pressure for silicon carbide and graphite is also shown.

11. KEY WORDS

Physics
Chemistry
Thermodynamics